SPECIFICATION

TITLE OF THE INVENTION

IMAGE PICK-UP METHOD AND IMAGE PICK-UP SYSTEM

BACKGROUND OF THE INVENTION

1.   Field of the Invention

The present invention relates to an image pick-up method and an image pick-up system of a mobile-type camera system used for location of movies and television programs, and more specifically to an image pick-up method and an image pick-up system of a mobile-type camera system suitable for shooting in virtual studios.

2.   Description of the Related Art

When shooting in a studio, a mobile-type camera system is used and it has a structure in which a pan head is set on a mobile base called pedestal, and a camera is placed on the pan head. Then, a cameraman shoots a scene while moving the pedestal so as to change the camera angle appropriately.

In a virtual studio, for example, there is a case where a real object image taken with the camera system in the studio and computer graphics (CG) created as its background or effect, are operated together in relation with each other while maintaining the three-dimensional relationship in position as viewed from the camera position. In such a case, techniques of analyzing the

two-dimensional position of the pedestal in the virtual

space, as well as the position and angle of the camera

set on the pedestal, are employed. That is, according

to these techniques, when the two-dimensional position

of the pedestal and the position and angle of the

camera are determined, the relationship among the

positions of the pedestal, camera, an object and CG can

be found out by calculation. In this manner, the object

taken by the camera and the CG image can be combined

and moved together in relation with each other while

maintaining the three-dimensional relationship between

the positions of the object and the CG image.

The following are some of the examples of the

conventional techniques proposed in consideration of

the above.

(1) The method of recognizing the two-dimensional

position of a pedestal, wherein a great number of

position marks are made on the ceiling of the studio,

and as the sensor provided on the pedestal reads some

of the marks, the read marks are image-processed,

thereby to recognize the position of the pedestal.

(2) The method of detecting the position of a

pedestal, wherein a marker is set on the pedestal and

the marker is read by a plurality of detection cameras

provided in the studio, thereby to detect the position

of the pedestal.

(3) The method of recognizing the pedestal,

wherein a mark such as a bar code, which is included in the blue-back image taken with the studio camera as the background, is read by a detector, and the view corresponding the mark is image-processed, thereby to recognize the position of the pedestal.

(4) The method of detecting the position of a pedestal, wherein rails are laid in the studio and the pedestal are run on them while detecting the distance of the movement.

However, the above-described methods entail the following drawbacks, respectively.

First, as to the method (1), in some cases, position marks cannot be read from the position of the pedestal. More specifically, there are, usually, a great number of lighting tools which are suspended from the ceiling of a studio, and some of them physically block the view. Further, the reading of a position mark may be disturbed by illumination light.

As to the method (2), as the detectable area is widened, a greater number of detection cameras are required, thus increasing the cost.

As to the method (3), a mark included in the background image must be always located within the view of the camera, and therefore the movable range of the camera is limited. Further, when the size of the object increases in the image, such as in zoom-in for close-ups, etc., the ratio of the mark included in the

background image may be excessively decreased as compared to the whole scene, thus making it impossible to detect it in the image.

As to the method (4), the movement of the camera is limited by the tracks of the rails, and therefore the applicability is low.

With any of the above-described methods, it is difficult to detect the positional relationship between the camera and the object to be shot at a high accuracy.

BRIEF SUMMARY OF THE INVENTION

The object of the present invention is to provide an image pick-up method and an image pick-up system which can find the relationship in position between the camera and an object at a high accuracy, inexpensively and without causing limitation to shooting.

According to an aspect of the present invention, there is provided an image pick-up method for picking up an image of an object with a camera mounted via a pan head on a moving pedestal, comprising the steps of: setting a reference position on a floor surface on which the moving pedestal moves, and a reference angle of the moving pedestal; detecting a moving amount of the moving pedestal from said reference position and a rotation angle thereof from said reference angle; finding a position and an angle of the camera with respect to the object on the basis of said reference position, said reference angle, said moving amount and

said rotation angle of the moving pedestal; and transmitting data of the position and the angle of the camera with respect to the object, to a computer for creating an image containing a real object image of the object taken with the camera.

According another aspect of the present invention, there is provided an image pick-up system for picking up an image of an object, comprising: a camera unit having a structure in which a camera for picking up an image of an object, is mounted via a pan head on a moving pedestal; an operation means for calculating a positional relationship between the camera and the object; a setting means for setting a reference position on a floor surface on which the moving pedestal moves, and a reference angle of the moving pedestal to said operation means; and a detection means for detecting a moving amount of the moving pedestal from the reference position, and a rotation angle thereof from the reference angle, wherein said operation means calculates out a position and an angle of the camera with respect to the object on the basis of the reference position, the reference angle, the moving amount and the rotation angle of the moving pedestal, and transmits data of the position and the angle of the camera with respect to the object, to a computer for creating an image containing a real object image of the object taken with the camera.

According still another aspect of the present invention, there is provided an image pick-up system for picking up an image of an object, comprising: a moving pedestal including three wheels; a camera unit having a structure in which a camera for picking up an image of an object, is mounted via a pan head on said moving pedestal; an operation means for calculating a positional relationship between the camera and the object; three encoders provided respectively for the three wheels of said moving pedestal; a plurality of sensors provided on said moving pedestal, for detecting a predetermined mark made on a floor surface on which said moving pedestal moves; and a setting means for setting a reference position on the floor surface, and a reference angle of said moving pedestal, which are found from detection values of said plurality of sensors and a pulse numbers counted by said encoders in the movement of said moving pedestal, to said operation means, wherein said operation means calculates out a position and an angle of the camera with respect to the object on the basis of the reference position, the reference angle, the moving amount and the rotation angle of said moving pedestal, which are obtained from the pulse numbers counted by said encoders, and transmits data of the position and the angle of the camera with respect to the object, to a computer for creating an image containing a real object image of the

object taken with the camera.

According to the present invention, the reference position is set on the floor surface on which the moving pedestal is moved around, and the moving amount of the pedestal from the reference position and the rotation angle from the reference angle are detected. Thus, from the reference position, the reference angle, the moving amount of the moving pedestal and the rotation angle thereof, the position and angle of the camera with respect to the object can be found. In this manner, the positional relationship between the camera and the object can be found without especially providing costly facilities or without limiting the shooting operation. In addition to that, the moving pedestal can be moved around at random, and therefore present invention has a high applicability. Further, an error created due to the change in the tire diameter of the moving pedestal, or the change in the angle of the moving pedestal can be suppressed to a very low level, and therefore the position and the angle of the moving pedestal can be accurately found. As a result, an image containing the real object image shot with the camera can be created at a high accuracy.

In the present invention, it is desirable to obtain the moving amount of the moving pedestal by measuring a length of a portion of the wheel of the moving pedestal, which has been brought into contact

with the floor surface. As a result, the moving distance of the moving pedestal can be accurately found.

The rotation angle of the moving pedestal can be calculated from the moving distances of two of at least three wheels of the pedestal, which are distant with respect to the moving direction. In this manner, the angle of the moving pedestal can be accurately found. Further, the two wheels can be selected which are most distant. In this manner, the angle of the moving pedestal can be more accurately found.

Further, in the present invention, the first and second lines are formed on the floor surface so that they normally cross with each other from the reference position, and two of the first sensors for detecting the first line and one second sensor for detecting the second line are provided on the moving pedestal, and the reference position and the reference angle can be found on the basis of the moving amount at a time when the two first sensors each pass the first line, and the moving amount at a time when the second sensor passes the second line. In this manner, the reference position and reference angle of the moving pedestal can be easily found.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification,

illustrate presently preferred embodiments of the invention, and together with the general description given above and the detail description of the preferred embodiments given below, serve to explain the

5   principles of the invention.

FIG. 1 is a side view of a TV camera unit used in the image pick-up method according to the present invention;

FIG. 2 is a plan view of the TV camera unit used

10 in the image pick-up method according to the present invention;

FIG. 3 is a block diagram showing an image pick-up system according to an embodiment of the present invention;

15 FIG. 4 is a flowchart illustrating the image-pick up method of the present invention;

FIG. 5 is a schematic diagram illustrating how a real object image taken with the TV camera and a virtual image projected on a virtual screen in its

20 background are operated in relation with each other, using the method of the present invention;

FIG. 6 is a diagram illustrating how to obtain the moving distance of a wheel in the embodiment;

FIG. 7A is a diagram illustrating a method of

25 recognizing and setting a reference position on the surface of a floor on which the pedestal is run, and a reference angle of the pedestal;

FIG. 7B is a diagram illustrating a specific method for calculating the correction of the angle of the pedestal;

FIG. 8 is a diagram illustrating an example of a preferable reference point passing point; and

FIG. 9 is a diagram illustrating how to select two wheels used to calculate the rotation angle of the pedestal.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will now be described with reference to accompanying drawings.

FIG. 1 is a side view of a TV camera unit used in the image pick-up method according to the present invention, and FIG. 2 is a plan view thereof. A TV camera unit 1 includes a pedestal 2 serving as a moving base which runs on the floor surface of a studio, a pan head 3 set thereon, and a TV camera 4 mounted on the pan head 3, and the TV camera 4 can be rotated and tilted by means of the pan head 3. Also shown are a handle 5 used for changing the moving direction of the pedestal, and a lever 6 used for tilting or rotating the TV camera 4.

The pedestal 2 has a bottom portion provided with three running wheels 7a, 7b and 7c. Further, the bottom portion of the pedestal 2 has two of first optical sensors 8a and 8b, and one second optical sensor 9,

which are used to set or correct the reference position and reference angle of the pedestal 2.

Next, the image pick-up system according to an embodiment of the present invention, in which the

5 above-described camera unit 1 is used, and the image pick-up method using such a system will now be described with reference to the block diagram shown in FIG. 3 and the flowchart provided in FIG. 4.

As shown in the FIG. 3, encoders 11a, 11b and 11c

10 for detecting the running distance (movement amount) are connected to the rotation shafts of the wheels 7a, 7b and 7c of the pedestal 2. These encoders 11a, 11b, 11c, the first optical sensors 8a and 8b and the second optical sensor 9 are connected to a reference setting

15 section 12. On the basis of data sent from the encoders 11a, 11b, 11c, the first optical sensors 8a and 8b and the second optical sensor 9, the reference position on the floor surface on which the pedestal 2 travels as well as the reference angle of the pedestal 2 are

20 obtained by the reference setting section 12 as will be described later, and these data are set to an arithmetic operation section 13 (STEP 1 in FIG. 4). Further, other data such the steering angle of the pedestal 2, the panning and tilting of the pan head 3,

25 the zooming and focusing of the TV camera 4 are also inputted to the arithmetic operation section 13.

As the pedestal 2 runs on the floor surface, the

running distance (movement amount) of the wheels 7a, 7b

and 7c are detected by the encoders 11a, 11b and 11c,

and then, based on these detected values, the movement

amount of the pedestal 2 from the reference position

5 and the rotation angle from the reference angle are

calculated by the operation section 13 (STEP 2 in FIG.

4).

After that, from the data of the reference

position and reference angle sent from the reference

10 setting section 12, the movement amount of the pedestal

2 and the data of the rotation angle obtained from the

reference angle, the position and angle of the TV

camera 4 with respect to the object are calculated by

the operation section 13 (STEP 3 in FIG. 4).

15 The data of the position and angle of the TV

camera 4 with respect to the object, which are

calculated by the operation section 13, are sent to an

image forming computer 14 (STEP 4 in FIG. 4). The image

forming computer 14 is able to operate a real object

20 image (shot point 20) taken with the TV camera 4 and a

virtual image projected on a virtual screen 30 in

background of the real object, in relation with each

other.

The moving amount of the pedestal 2 is measured

25 with use of the encoders 11a, 11b and 11c mounted on

the rotation shafts of the wheels 7a, 7b and 7c,

respectively, as described above. The measurement of

the moving amount with use of encodes is carried out in
the following manner. That is, generally, the moving
amount is calculated by dividing the diameter of the
wheel with the number of pulse per one rotation

5   detected by the encoder. However, the wheels (usually
three of them) of the cart of the pedestal 2 are
usually made of rubber, and therefore the contact state
between the wheels and the floor surface varies from a
case of running straight to a case of making a turn,

10   thereby changing the diameter of the tire at the
contact portion. Therefore, if the moving amount is
measured directly from the rotation of the shaft and
the diameter of the wheels, an error results and the
measurement is not accurate.

15   In order to avoid such a drawback, as shown in FIG.
6, this embodiment provides a roller 15 whose diameter
is known to each wheel (wheel 7a in FIG.6). In this
case, the roller 15 rotates along with the rotation of
the wheel, and therefore when the rotation number of

20   the roller 15 is known, the length of a portion of the
wheel, which is brought into contact with the floor,
can be accurately detected regardless of the state of
the wheel. More specifically, when the diameter of the
roller 15 is divided by the pulse number per one

25   rotation, the moving amount of the roller 15 is
calculated. Here, even if the wheel is worn out, as
long as the roller 15 is in contact with the wheel, the

moving amount of the wheel can be accurately obtained from this calculated value of the roller.

Next, the method of setting data to the arithmetic operation section 13 by first recognizing the reference position on the floor surface on which the pedestal 2 moves around, and the reference angle of the pedestal 2, will now be described.

As shown in FIG. 7A, an X-axis and a Y-axis are formed with an origin corresponding to the reference position on the floor, and the pedestal 2 is moved around. Then, the difference in count between the encoders 11a and 11b of the wheels 7a and 7b at an instantaneous moment when the first optical sensors 8a and 8b pass the X-axis, which is the Y origin, is calculated. Based on thus calculated difference, the angle of the pedestal 2 is corrected, and the Y origin is calculated. Subsequently, on the basis of the position at an instantaneous moment when the second optical sensor 9 passes the X origin, the position of the X origin is calculated out from the current angle correction value. It should be noted that in this figure, the first optical sensors 8a and 8b, and the second optical sensor 9 are indicated in the form of arrows directed towards the line to be detected.

Next, an angle correction calculating method will now be described concretely with reference to FIG. 7B. Let us suppose that the steering angle of the handle 5

is θ, the distance between the two first optical

sensors 8a and 8b is M, and the distance between the

line connecting the centers of the first optical

sensors 8a and 8b, and the second optical sensor 9 is S.

5   First, the pedestal 2 is placed close to the originally

set origin. Then, the pedestal 2 is moved such that the

first optical sensors 8a and 8b cross the X axis, and

the rotation angle $\Delta\theta$ of the pedestal 2 when the first

optical sensor 8b crosses the X axis is obtained. FIG.

10   7A illustrates the just-mentioned status. Here, where

the distances which the wheels 7a and 7b have moved

until the first optical sensor 8b crosses the X axis

are represented by a and b, respectively, $\Delta\theta$, ΔX and

ΔY of FIG. 7B are given by the following formulas,

15   respectively:

$$\Delta\theta = \tan^{-1} ((a - b) \cos\theta /(M - (a - b) \sin\theta))$$

$$\Delta Y = (M/2) \sin\Delta\theta$$

$$\Delta X = S \sin\Delta\theta .$$

Since values a and b can be obtained from the

20   counts of the encoders 11a and 11b mounted on the

wheels 7a and 7b, the rotation angle $\Delta\theta$ of the

pedestal 2 can be obtained from the equation.

After that, the pedestal 2 is moved further only a

small distance, so as to obtain new values a and b.

25   From the newly obtained values and b, a new $\Delta\theta$ for the

small distance is obtained. If thus newly obtained $\Delta\theta$

value is added to the previously obtained $\Delta\theta$ value, the

rotation angle for the small distance moved can be known. Therefore, from the newly obtained values of a, b and $\Delta\theta$, the position of the pedestal when it is moved by a small distance, can be known. Then, by

5   repeating the above-described operation, the position and rotation angle of the pedestal 2 can be detected at all times.

Further, in order to set the reference position at a high accuracy (correction of origin), it is

10   preferable that a reference position passing point should be formed by combining two kinds of plate members 21 and 22 of different colors (for example, of hard vinyl chloride plate) together as shown in FIG. 8. In this manner, the horizontality and verticality can

15   be guaranteed by the accuracy of the cut surface of the plate members, and therefore the reference position can be set at a high accuracy.

The rotation angle of the pedestal 2 can be calculated from the difference in moving distance

20   between two of the three wheels of the pedestal 2 using the following equation:

$$\Delta\theta = \tan^{-1}\{(a - b)/Nc\}$$

where a and b represent moving distances of the two wheels 7a and 7b, respectively, and Nc represents

25   the distance between the wheels 7a and 7b.

The above-described results are obtained in connection with the case where a pair of wheels 7a and

7b are focused to calculate out ΔX, ΔY, $\theta \Delta$; however it is also possible to consider some other cases such as a pair of wheels 7b and 7c, and a pair of wheels 7a and 7c for the calculation as long as the wheels are

5   distant in term of a moving direction.

This embodiment is characterized by how to select which two of the three wheels should be selected for the calculation, and a pair of wheels most distant in terms of the moving direction should be selected. More

10   specifically, as shown in FIG. 9, let us draw lines L1, L2 and L3 which pass the center of the three wheels 7a, 7b and 7c, and are parallel to the moving direction. Then, the distance Na between L1 and L2, the distance Nb between L2 and L3, and the distance Nc between L3

15   and L1 are measured, and such a pair of wheels that have the longest distance should be selected. In the case shown in FIG. 9, the distance Nb is the longest and therefore the wheels 7b and 7c are selected. With this selection, the rotation angle can be calculated at

20   a high accuracy.

It should be noted here that the moving direction is determined by the steering angle of the ring-shaped handle 5 mounted on the pedestal 2, and therefore subject wheels for the calculation may be automatically

25   selected on the basis of the steering angle of the handle 5 by presetting, or the optical wheels may be selected by the computer mounted on the pedestal 2.

The embodiments described above are simply intended to clarify the technical concept of the present invention. Of course, the present invention should not be limited to the embodiments described

5   above in interpreting the technical scope of the present invention. The present invention can be worked in variously modified fashions within the spirit of the present invention and within the scope defined by the accompanying claims. For example, the above-described

10   embodiment is discussed in connection with a case where a real shot image and a virtual image are synthesized together; however the invention is not limited to this embodiment, but can be applied to a case where real object images are synthesized together. Further, the

15   synthesis of images can be carried out in real time or later in editing. Naturally, the shape of the pedestal is not limited to the above embodiment. The number of wheels may be more than three. Further, the detection method of the moving amount, and the setting method for

20   the reference position and reference angle, etc. are not limited to the embodiment.